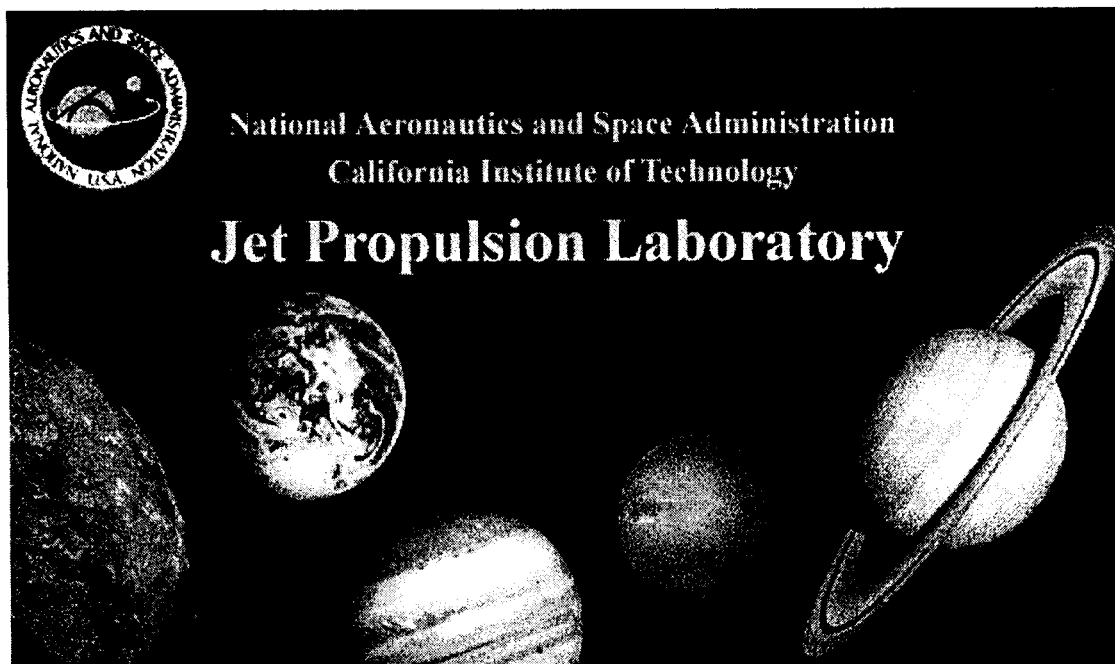


IEEE International Frequency Control Symposium 1998

Commercial Off-The-Shelf (COTS)

**A Study of Plastic Encapsulated
Microcircuits (PEMs) in JPL Space Hardware**



Mike Sandor & Shri Agarwal



Agenda

Introduction to COTS

COTS Work Plan/Status

COTS Work for Plastic Packages

Summary



The Meaning of COTS

- “Buy and Fly”
- “Procuring via catalog part number to QML-V standards”
- “Procurement is performed without formal specification”
- “The usage of any COTS equipment does not constitute any waiver to fundamental applicable requirements”

Our Interpretation:

COTS are parts whose specification is manufacturer-controlled as opposed to traditional “Hi-Rel” parts whose specification was Government or customer-controlled



Why Put COTS in Space ?

- 1. The availability of COTS parts is proliferating.**
- 2. COTS parts performance capabilities continue to increase (e.g. processing power & high density memories)**
- 3. A new generation of leading COTS IC technologies is introduced every 3 years.**
- 4. COTS parts typically cost much less than radiation hardened counterparts; by using radiation tolerant parts the cost advantage can be preserved.**
- 5. Some COTS parts (plastic) have been reported to demonstrate good to excellent reliability.**



JPL's Concerns About Using COTS

- **Reliability/RH of PEMS vs Traditional Ceramic**
- **Non Rad Hard Designed (maybe Rad Tolerant)**
- **Narrow Temperature Range**
- **Process/Designs Change Frequently**









**Examples of Risk Indicators & Their
Relative Costs for a Plastic Package:**

• Temperature Humidity	➡	Corrosion	(\$)
• Temperature Cycling	➡	Assembly Defects	(\$)
• Moisture Absorption	➡	Popcorning	(\$\$)
• Radiation	➡	TID Degradation	(\$\$\$\$)
• Outgassing	➡	Condensables	(\$\$)
• Glass Transition	➡	Stability	(\$\$)

(\$) indicates relative cost to perform the test
necessary to validate the risk.

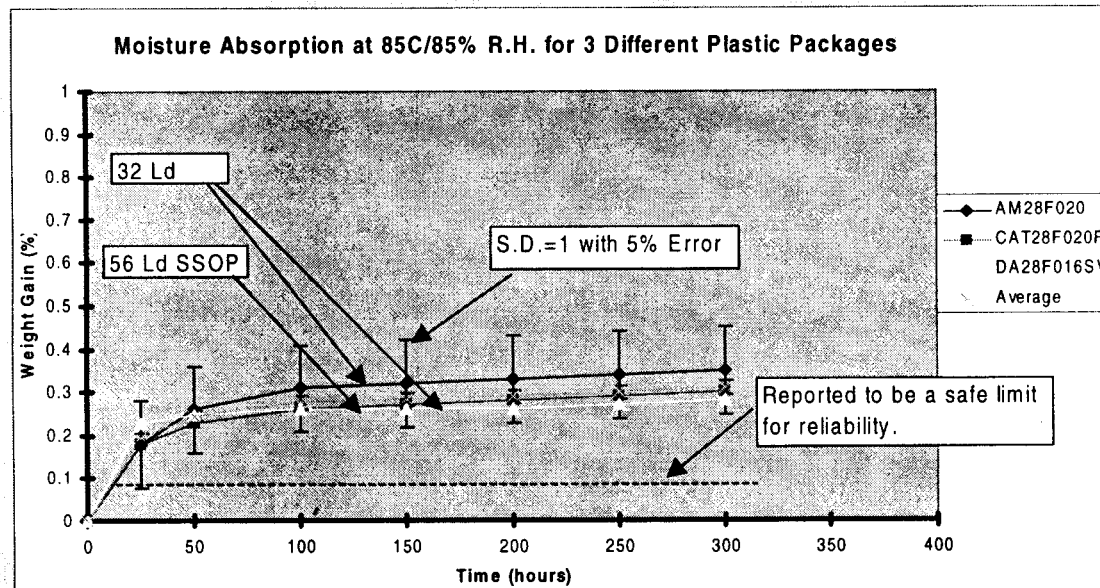


Work Conducted at JPL:

-  **Moisture Absorption/Desorption Characterization**
-  **Moisture Absorption Modeling**
-  **Acoustic Microscopy (C-SAM & Failure Analysis)**
-  **Radiation Testing of Dry vs Saturated PEMs**
-  **Outgassing Testing**
-  **Glass Transition Measurements**

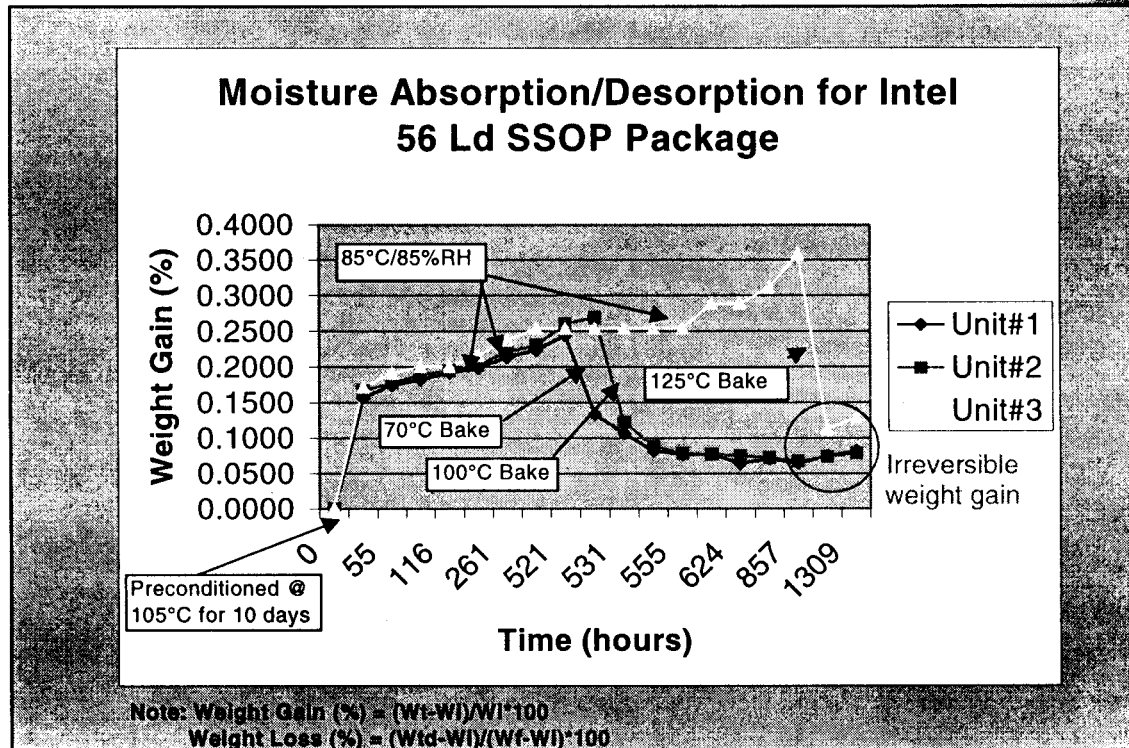
This work was done to ascertain plastic package reliability issues.

JET PROPULSION LABORATORY
Electronic Parts Engineering Office



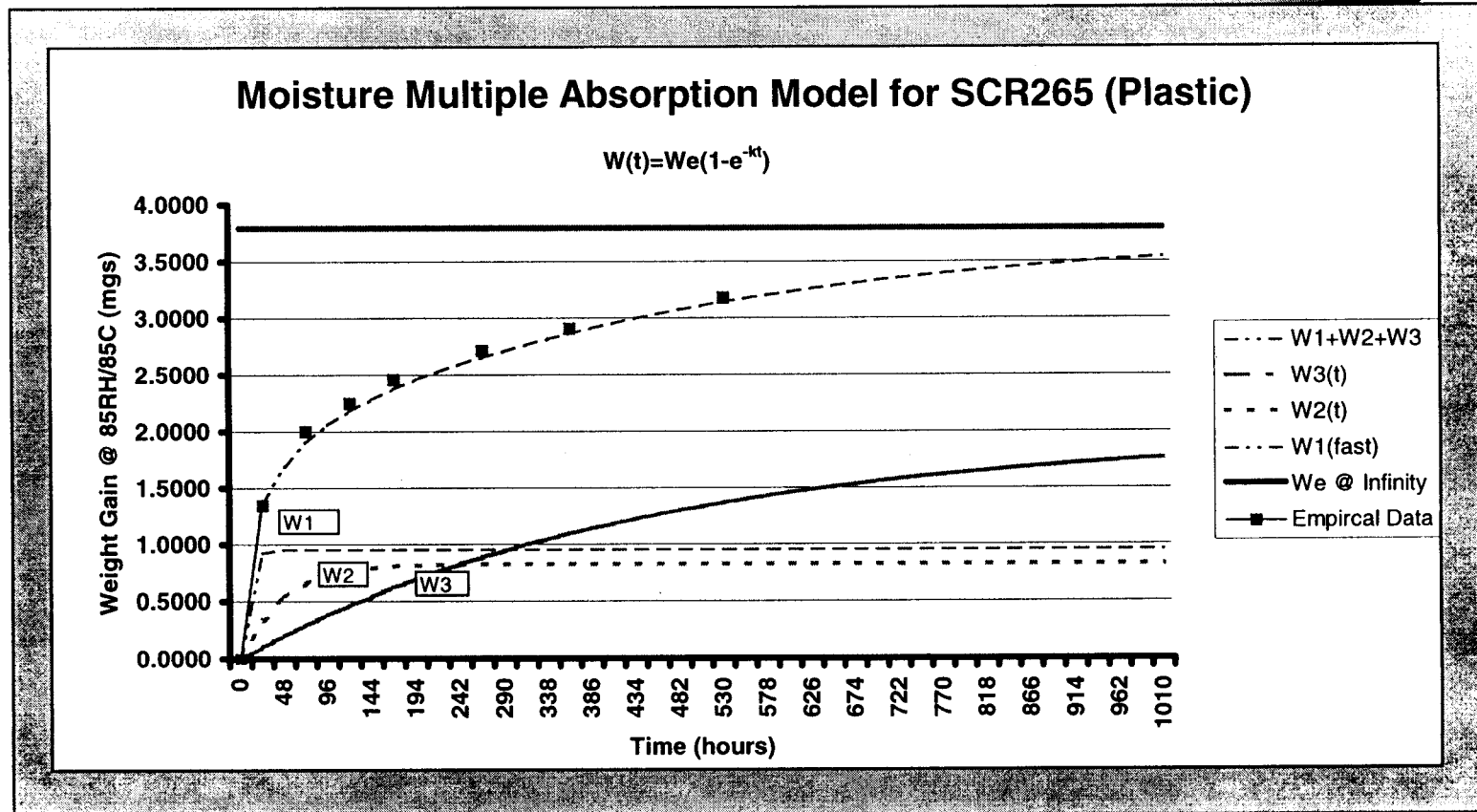
Conclusion: Most if not all plastic parts will absorb moisture >> 0.1% weight gain.

Plots shows the relative weight gain for different plastic packages during moisture absorption. The plots validate that all packages absorb moisture above 0.1% which is considered to be a safe margin.



Plots show different rates of desorption as a function of bake temperature. The higher the bake temperature, the faster is moisture desorption out of the package. The irreversible weight gain shows that moisture may not always be baked out.

JET PROPULSION LABORATORY
Electronic Parts Engineering Office

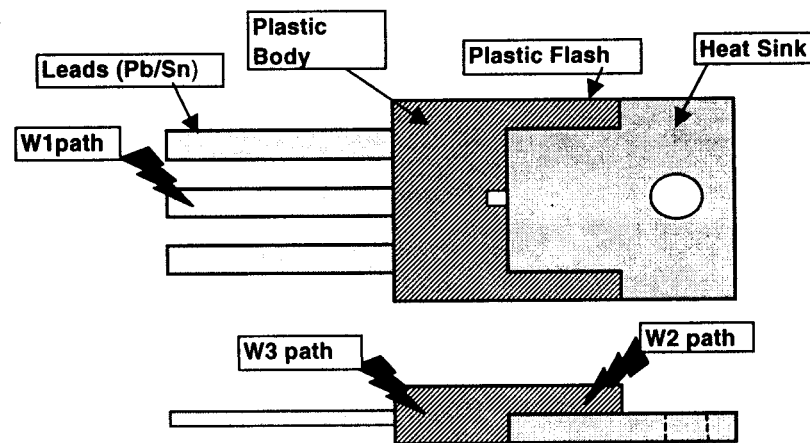


These plots show that the single moisture absorption plot is a composite of three different absorption mechanisms.



85%RH/85°C Moisture Absorption Mechanisms for SCR265

- **W1(t): Fast Irreversible Weight Gain ≤ 24 hours (~1mg)**
 - **W2(t): Intermediate Reversible Weight Gain, 80 to 140 hours**
 - **W3(t): Slowest Reversible Weight Gain, Reaches W_e @ $t=\infty$**
- SCR265 Package**



JET PROPULSION LABORATORY
Electronic Parts Engineering Office

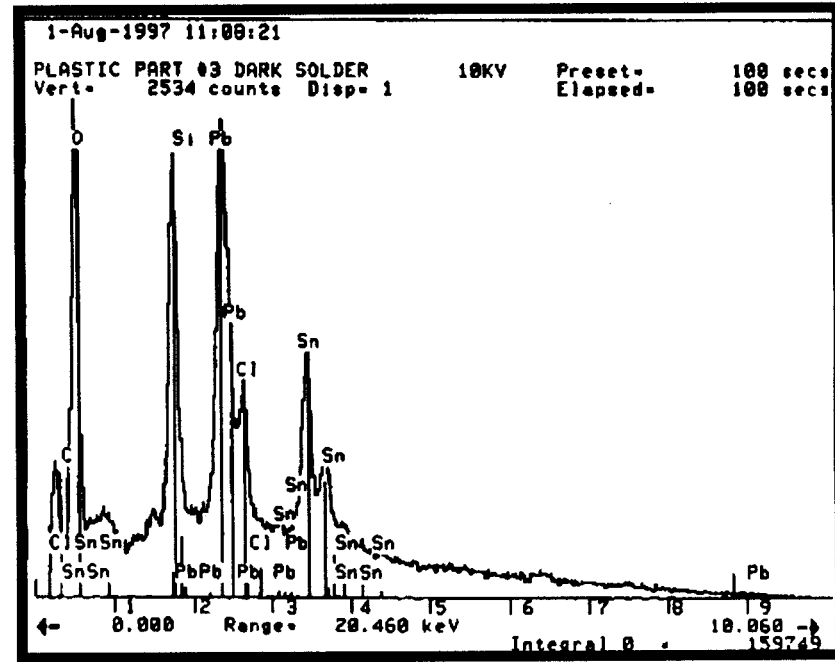
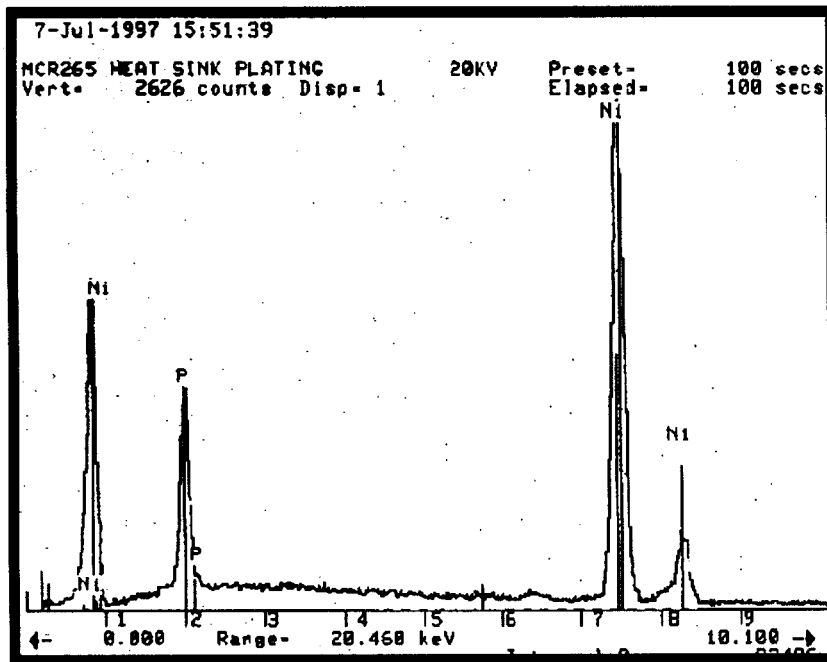


Nickel Plated Heatsink
Shows No Oxidation

Post 85%RH/85°C for SCR265

Leads Show Extreme Oxidation

→ W1(t)



Conclusion: Weight gain is solely attributed to oxidation of leads. The internal chip has miniscule Al area available for oxidation because of Cu intermetallic bonding to the Al.

JET PROPULSION LABORATORY
Electronic Parts Engineering Office



Outgassing Results of Plastic Packages

Material	MCR			7612382FBA, E24, DA28F016SV, K8055, U6240332			AM28F020-150PC, 9618FBB			CSI, CAT28F020F, 1-15 09550B		
Part	Motorola SCR			Intel 16 M Flash Memory			AMD 2M Flash Memory			Catalyst 2M Flash Memory		
Sample No.	5	6		7	8	a	9	10		11	24	
WT. Loss %	0.45	0.46	0.45	0.23	0.22	0.22	0.41	0.45	0.43	0.40	0.41	0.40
Water Vapor Recovered, WVR,	0.28	0.25	0.26	0.14	0.11	0.12	0.19	0.17	0.18	0.21	0.18	0.19
%TML (WT, LOSS- WVR) %	0.17	0.21	0.19	0.09	0.11	0.10	0.22	0.28	0.25	0.19	0.23	0.21
CVCM %	0.04	0.08	0.06	0.02	0.01	0.01	0.03	0.05	0.04	0.04	0.04	0.04
DEPOSIT on CP	Opaque			Negligible			Opaque			Opaque		
FTIR Results	Amine cured epoxy			Anhydride cured epoxy			Amine cured epoxy			Amine cured epoxy		

Conclusion: All materials passed. These tests are suited for lot-to-lot comparisons, tracking manufacturing continuity/changes, and measuring absorbed moisture at a known environment.

JET PROPULSION LABORATORY
Electronic Parts Engineering Office



Radiation of Plastic Parts

**Moisture Absorption / Bake for
 Intel DA28F016SV in Plastic Package**
 (0.6 μ m ETOX IV Process Technology)

Conditions: Test Temperature = 25°C, Vdd = 5.0V, Vpp = 5.0V

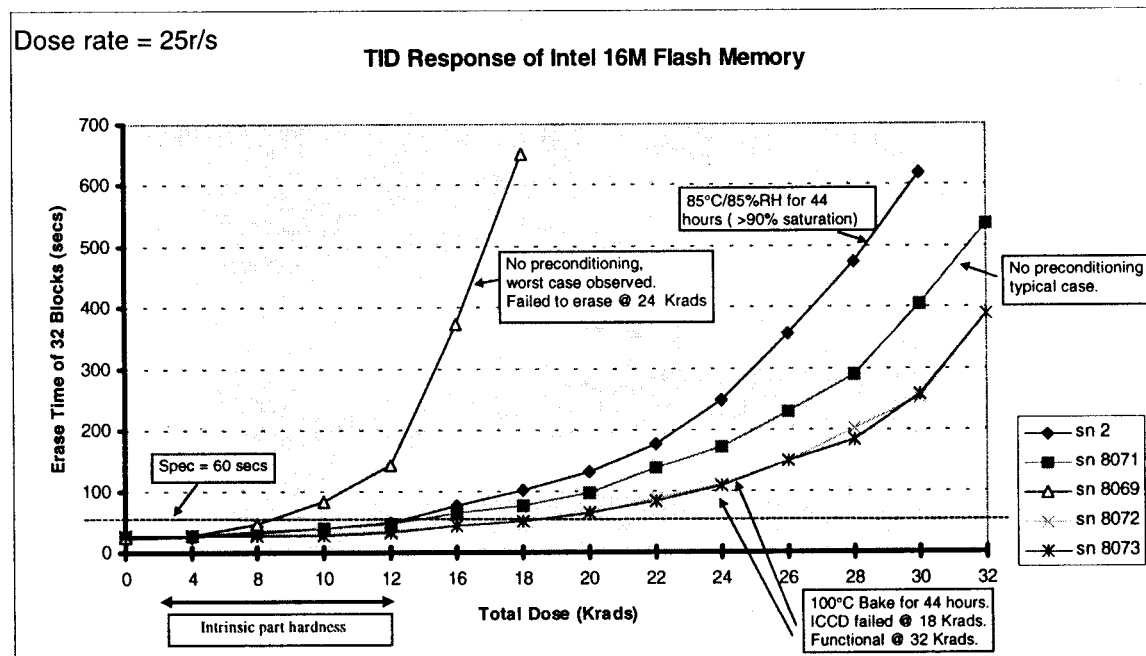


Figure 1
 Jet Propulsion Laboratory
 Electronic Parts Engineering Office 507

These plots show the erase time device parameter versus different preconditioning environments as a function of total dose radiation. High temperature bake has the best response.



Conclusion:

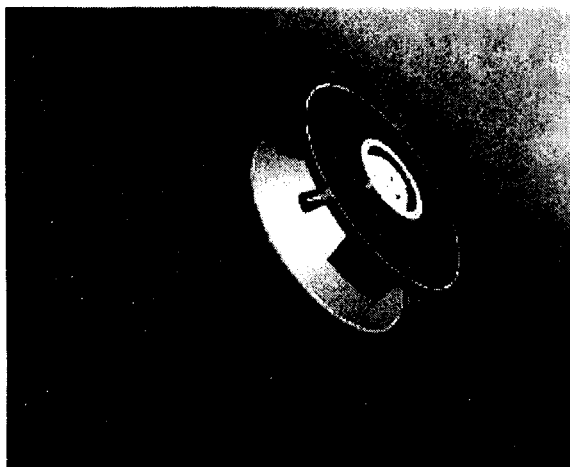
- Using plastic parts without understanding their pedigree can lead to mission delay or worst ➡ **Mission Failure**
- A methodology is in place in Office 507 to help JPL users of plastic parts ascertain their risk and acceptance for Space Application
- All risk factors should be evaluated when using COTS parts (quality, reliability, radiation, package, and device performance) in critical applications

JET PROPULSION LABORATORY
Electronic Parts Engineering Office

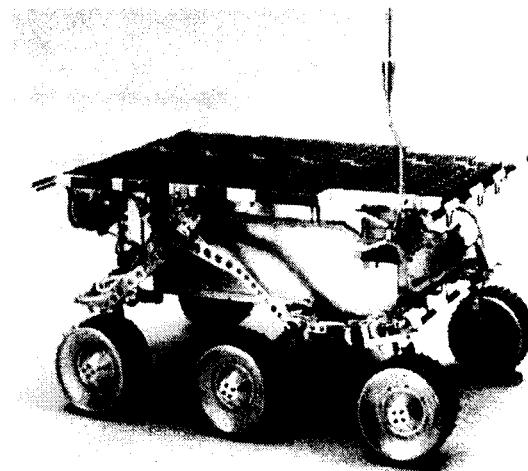


**Plastic Parts Successfully
Used For Mars Pathfinder:**

16 Mbit DRAM Used in Pathfinder
Flight Computer



FETs ; ASIC & Microcontroller
Used in Modem for Lander and
Rover



Passed 1000 Hours Life Test on Mars !